

Draft Synopsis V1.0  
Co-60 Total Ionizing Dose (TID) Testing of the Analog Devices  
OP-27 Operational Amplifier

Jim Howard<sup>1</sup> and Chris Palor<sup>2</sup>

1. Jackson and Tull Chartered Engineers
2. Orbital Science Inc.

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Report Date: September 29, 2003.

### I. Introduction

This study was undertaken to determine the total ionizing dose susceptibility of the Analog Devices OP-27 Operational Amplifier. The device was biased and operating when exposed to a Cobalt-60 environment at the Goddard Space Flight Center (GSFC) Co-60 Radiation Effects Facility.

### II. Devices Tested

Five parts were exposed for this testing. These devices were manufactured by Analog Devices and were characterized prior to exposure. The devices were from date code 0215. Complete device details are given in Table I.

### III. Test Facility

**Facility:** GSFC Co-60 Radiation Effects Facility

**Source:** Cobalt 60

**Dose Rate:** approximately 0.1 - 2 krad(Si)/hour

### IV. Test Methods

Five OP-27 devices (1, 2, 3, 4 and 5) were exposed to the Co-60 radiation environment while under bias. The bias circuit is shown in Figure 1, with  $V^+ = 5$  volts,  $V^- = -5$  volts and  $V_{in} = 3$  volts. The dose rate for the exposure ranged from 0.1 - 2 krad(Si)/hour.

The devices were characterized prior to entering the radiation chamber and at nine times during the exposure, the devices were removed to the Cobalt cell and characterized. The nine post exposure characterizations were done at approximately 1, 2, 4, 7, 9, 13, 17, 24 and 30 krad(Si). Finally, after the 30 krad(Si) exposure, the devices were placed in a 100 °C oven for approximately 1 week and were then characterized a final time. The complete listing of exposure dates and dose rates are given in Table II.

The parametric measurements done for this testing were performed using the Tektronix 2465A Parametric Analyzer, Analog Oscilloscope, 8116A Pulse/Function Generator, and a HP 6654A Power Supply. The parameters measured, the conditions for that measurement and the data sheet specifications are contained in Table III.

### V. Results

The results from the testing are detailed in Table IV. After 30 krad(Si) exposure and a 1 week 100 °C anneal, all parameters were within specification. Therefore, the OP-27 can be considered to have a total dose failure greater than 30 krad(Si).

TABLE I. Part Information

Generic Part Number:	OP27
GOES ITT Part Number	OP27
Charge Number:	
Manufacturer:	Analog Devices
Lot Date Code (LDC):	1D 0215FF
Quantity Tested:	6
Serial Number of Control Samples:	0
Serial Numbers of Radiation Samples:	1,2,3,4 and 5
Part Function:	Operational Amplifier
Part Technology:	Bipolar
Package Style:	8-Pin DIP
Test Equipment:	Parametric Analyzer, Tektronix 2465A Analog Oscilloscope, 8116A Pulse/Function Generator, HP 6654A Power Supply
Test Engineer:	Chris Palor

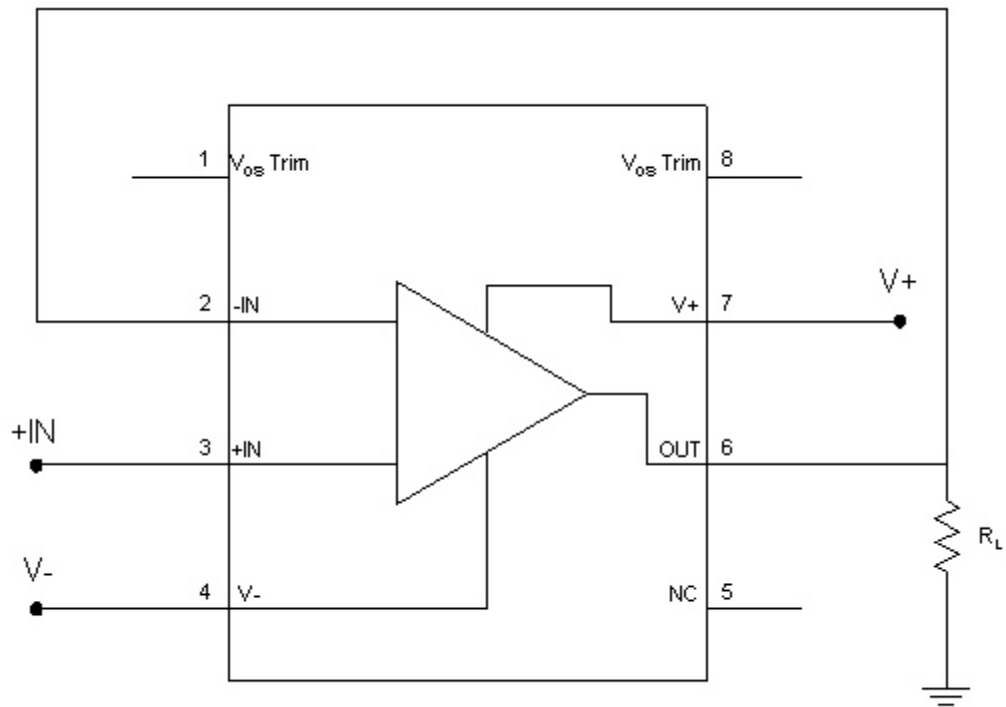


Figure 1. Radiation Bias Circuit for OP27

Notes:

1.  $R_L = 1K\Omega \pm 5\%$ .
2.  $+IN = 3.0V$ ,  $V_+ = +5V$ ,  $V_- = -5V$ .

TABLE II. Radiation Schedule for OP27

EVENT	DATE
1) INITIAL ELECTRICAL MEASUREMENTS	07/09/03
2) 1.0 KRAD IRRADIATION (1.000 KRADS/HOUR) POST-1.0 KRAD ELECTRICAL MEASUREMENT	07/09/03 07/09/03
3) 2.0 KRAD IRRADIATION (1.000 KRADS/HOUR) POST-2.0 KRAD ELECTRICAL MEASUREMENT	07/09/03 07/09/03
4) 4.0 KRAD IRRADIATION (1.000 KRADS/HOUR) POST-4.0 KRAD ELECTRICAL MEASUREMENT	07/10/03 07/10/03
5) 7.0 KRAD IRRADIATION (1.530 KRADS/HOUR) POST-7.0 KRAD ELECTRICAL MEASUREMENT	07/10/03 07/10/03
6) 9.0 KRAD IRRADIATION (0.2352 KRADS/HOUR) POST-9.0 KRAD ELECTRICAL MEASUREMENT	07/10/03 07/11/03
7) 13.0 KRAD IRRADIATION (2.000 KRADS/HOUR) POST-13.0 KRAD ELECTRICAL MEASUREMENT	07/11/03 07/11/03
8) 17.0 KRAD IRRADIATION (1.730 KRADS/HOUR) POST-17.0 KRAD ELECTRICAL MEASUREMENT	07/11/03 07/11/03
9) 24.0 KRAD IRRADIATION (0.1098 KRADS/HOUR) POST-24.0 KRAD ELECTRICAL MEASUREMENT	07/11/03 07/14/03
10) 30.0 KRAD IRRADIATION (0.3072 KRADS/HOUR) POST-30.0 KRAD ELECTRICAL MEASUREMENT	07/14/03 07/15/03
11) 168 HOUR ANNEALING @25°C POST-168 HOUR ANNEAL ELECTRICAL MEASUREMENT	07/21/03 07/21/03

PARTS WERE IRRADIATED AND ANNEALED UNDER BIAS, SEE FIGURE 1.

Table III. Electrical Characteristics of OP-27

Test #	Parameter	Units	Test Conditions	Spec. min	Lim. max
1	+I <sub>cc</sub>	mA	+V <sub>S</sub> = 15V, V <sub>O</sub> = 0V	0.0	4.67
2	-I <sub>cc</sub>	mA	-V <sub>S</sub> = -15V, V <sub>O</sub> = 0V	-4.67	0.0
3	Power_Diss	mW	V <sub>CC</sub> = ±15V, V <sub>O</sub> = 0V		140
4	V <sub>OS</sub>	μV	+V <sub>S</sub> = 15V, -V <sub>S</sub> = -15V, warmed up	-25	25
5	P <sub>IIB</sub>	nA	+V <sub>S</sub> = 15V, -V <sub>S</sub> = -15V	-40	40
6	N <sub>IIB</sub>	nA	+V <sub>S</sub> = 15V, -V <sub>S</sub> = -15V	-40	40
7	I <sub>IOS</sub>	nA	+V <sub>S</sub> = 15V, -V <sub>S</sub> = -15V	-35	35
8	CMRR	dB	V <sub>CM</sub> = ±11V	114	
9	PSRR	dB	+V <sub>S</sub> = ±4V to ±18V	100	
10	P_VOUT_2k	V	R <sub>L</sub> = 2kΩ	12.0	
11	N_VOUT_2k	V	R <sub>L</sub> = 2kΩ		-12.0
12	P_VOUT_600	V	R <sub>L</sub> = 600Ω	10.0	
13	N_VOUT_600	V	R <sub>L</sub> = 600Ω		-10.0
14	P_AOL_2k	V/mV	R <sub>L</sub> = 2kΩ, V <sub>O</sub> = +10V	1000	
15	N_AOL_2k	V/mV	R <sub>L</sub> = 2kΩ, V <sub>O</sub> = -10V	1000	
16	P_AOL_600	V/mV	R <sub>L</sub> = 600Ω, V <sub>O</sub> = +10V	800	
17	N_AOL_600	V/mV	R <sub>L</sub> = 600Ω, V <sub>O</sub> = -10V	800	
18	Slew Rate	V/μs	C <sub>L</sub> = 100pF, R <sub>L</sub> = 2kΩ, V <sub>O</sub> = ±5V	1.70	

TABLE IV: Summary of Electrical Measurements after Total Dose Exposures and Annealing for OP27 /1, 2

Test					Total Dose Exposure (kRads Si)												Total Dose Exposure (kRads Si)								Annealing			
					Initial		1.0		2.0		4.0		7.0 /4		9.0		13.0		17.0		24.0		30.0		168 hours @25°C			
#	Parameters	Units	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd		
1	+Icc	mA	0.0	4.67	3.27	1.03E-04	3.23	9.73E-05	3.19	9.98E-05	3.12	1.08E-04	3.05	1.14E-04	3.03	1.16E-04	2.94	1.25E-04	2.86	1.29E-04	2.82	1.26E-04	2.75	1.27E-04	2.85	1.21E-04		
2	-Icc	mA	-4.67	0.0	-9.72	1.00E-04	-9.68	9.23E-05	-9.64	9.60E-05	-9.57	9.86E-05	-9.5	1.07E-04	-9.48	1.11E-04	-9.4	1.19E-04	-9.32	1.24E-04	-9.28	1.20E-04	-9.17	1.22E-04	-9.28	1.15E-04		
3	VOS	µV	-25	25	50.5	1.91E-06	50.1	1.32E-06	50	7.56E-07	50.1	7.87E-07	71.8	4.41E-05	-120	4.07E-05	50.3	1.15E-06	50.1	1.09E-06	49.9	5.11E-08	-148	1.89E-06	-9.64	5.42E-05		
4	P_IIB	nA	-40	40	8.19	1.41E-09	-4.24	3.16E-08	-2.46	3.37E-08	-1.46	3.73E-08	4	3.97E-08	-5.48	3.98E-08	2.78	4.27E-08	8.38	4.46E-08	-2.53	4.06E-08	-7.19	4.19E-08	130	3.16E-08		
5	N_IIB	nA	-40	40	-5.92	1.69E-09	-1.94	3.09E-08	-1.89	3.28E-08	-1.97	3.66E-08	-14.68	3.86E-08	-25	3.90E-08	-17.7	4.20E-08	-1.27	4.39E-08	-2.54	3.97E-08	-31.5	4.07E-08	111	3.06E-08		
6	P_VOUT_2k	V	12		13.4	5.67E-01	13.6	7.84E-01	13.56	4.77E-01	13.88	4.47E-02	13.92	4.47E-02	14	1.64E-02	14	3.52E-02	14	1.44E-02	14	1.19E-02	14	1.44E-02	14	1.05E-02		
7	N_VOUT_2k	V	-12		-13.8	1.01E-02	-13.8	1.68E-07	-13.8	1.68E-07	-13.8	1.69E-07	-13.8	1.69E-07	-13.8	1.08E-02	-13.8	1.18E-02	-13.8	1.20E-02	-13.8	1.20E-02	-13.8	1.09E-02	-13.8	1.36E-02		
8	GBW	MHz	5		10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0	10	0		
9	Slew Rate	V/µs	1.70		2.5	0	2.5	0	2.5	0	2.5	0	2.5	0	2.5	0	2.5	0	2.5	0	2.5	0	2.5	0	2.5	0		

Notes:

- 1/ +Icc, -Icc,N\_Vout and P\_IIB measurements were taken when Input Voltage to the Positive Input of the OP27 is at -300 µV.
- 2/ N\_IIB and P\_Vout measurements were taken when Input Voltage to the Positive Input of the OP27 is at +600 µV.
- 3/ These are manufacturer's pre-irradiation data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed.
- 4/ Due to a power outage, the devices were in the bias circuit overnight with no power, allowing some annealing to take place.

Radiation sensitive parameters:VOS, P\_IIB, N\_IIB .